Effectiveness of Pedestrian Crossing Treatments

by

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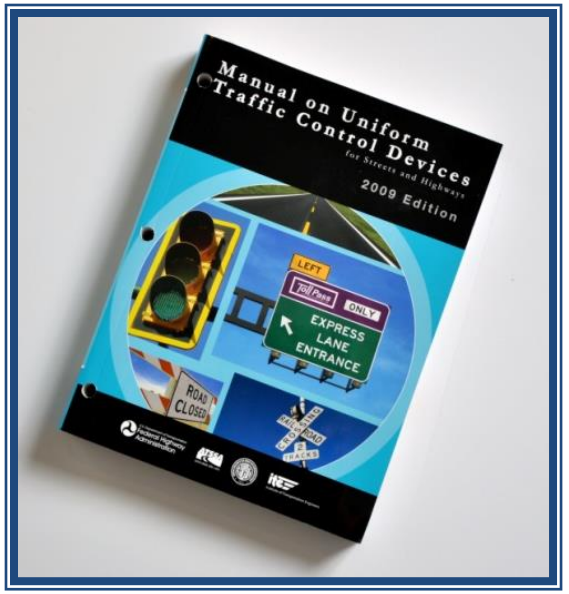
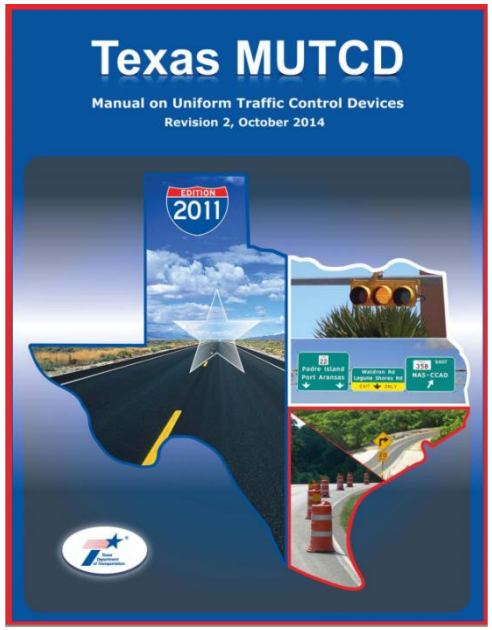
Key Abbreviations

- Ped = pedestrian
- HAWK = former name of PHB
- PHB = pedestrian hybrid beacon
- RFB = rapid flashing beacon
- RRFB = rectangular rapid flashing beacon
- CRFB = circular rapid flashing beacon
- Veh = vehicle
- CW = crosswalk

MUTCD

- Traffic control devices for pedestrian crossings - limited
- Signals (of course)
- Markings, warning signs
- In-roadway warning lights (in 2000 MUTCD)





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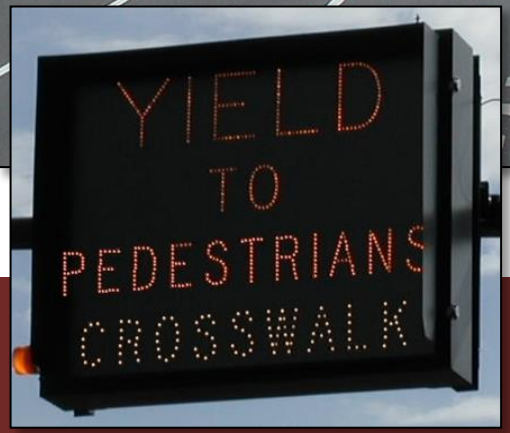
With Limited Options…. Non-Uniformity

- Lots of different solutions at pedestrian crossings

Photos: Richard Nassi



HAWK

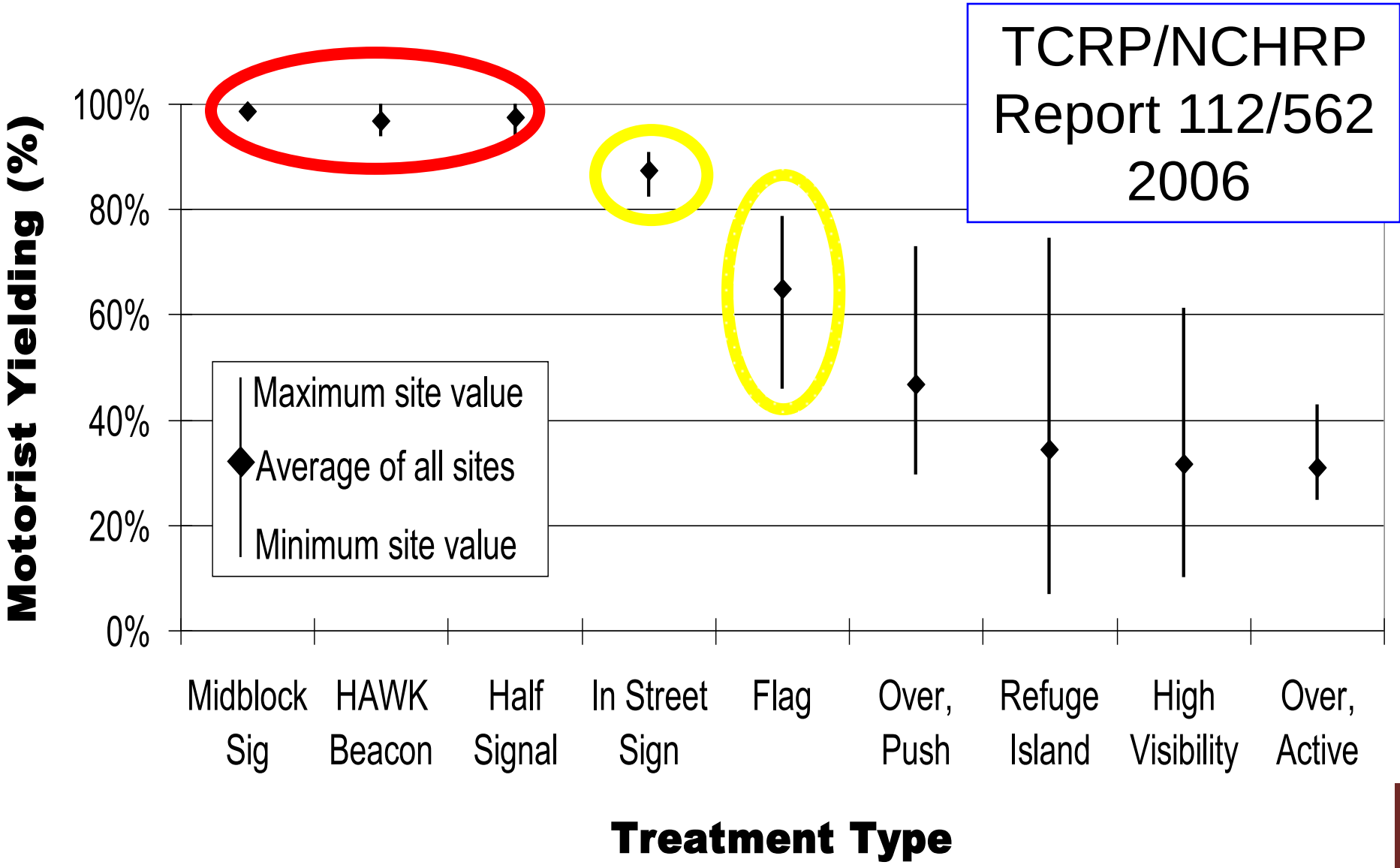
In the 2009 MUTCD and 2011 MMUTCD as Pedestrian Hybrid Beacon

Staged Pedestrian

- Ensures oncoming drivers receive consistent presentation of approaching pedestrian
- Member of research team wears: gray shirt, blue jeans, non-reflective shoes
- Flags used to indicate stopping distance upstream of site
- 2nd researcher gathers driver yielding / not yielding data

Photos: TTI

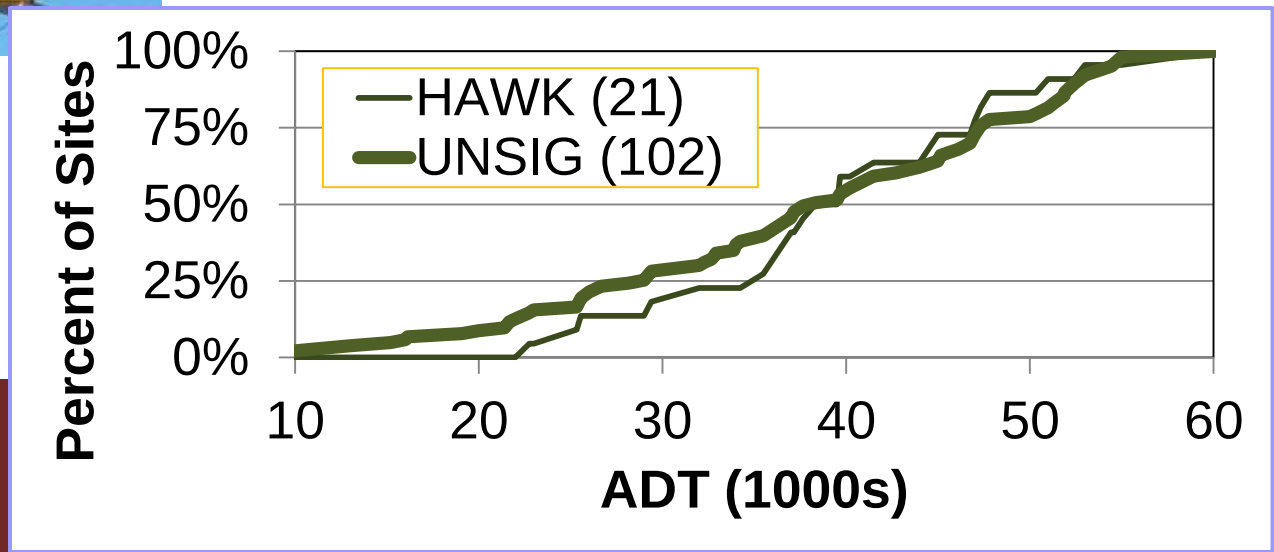
Driver Yielding



HAWK Safety Effectiveness

- Anecdotal evidence = yes
- FHWA-sponsored research (started 2007)
  - Comprehensive, before-after safety evaluation
  - Safety evaluation: Empirical Bayes method

Photo: Marcus Brewer



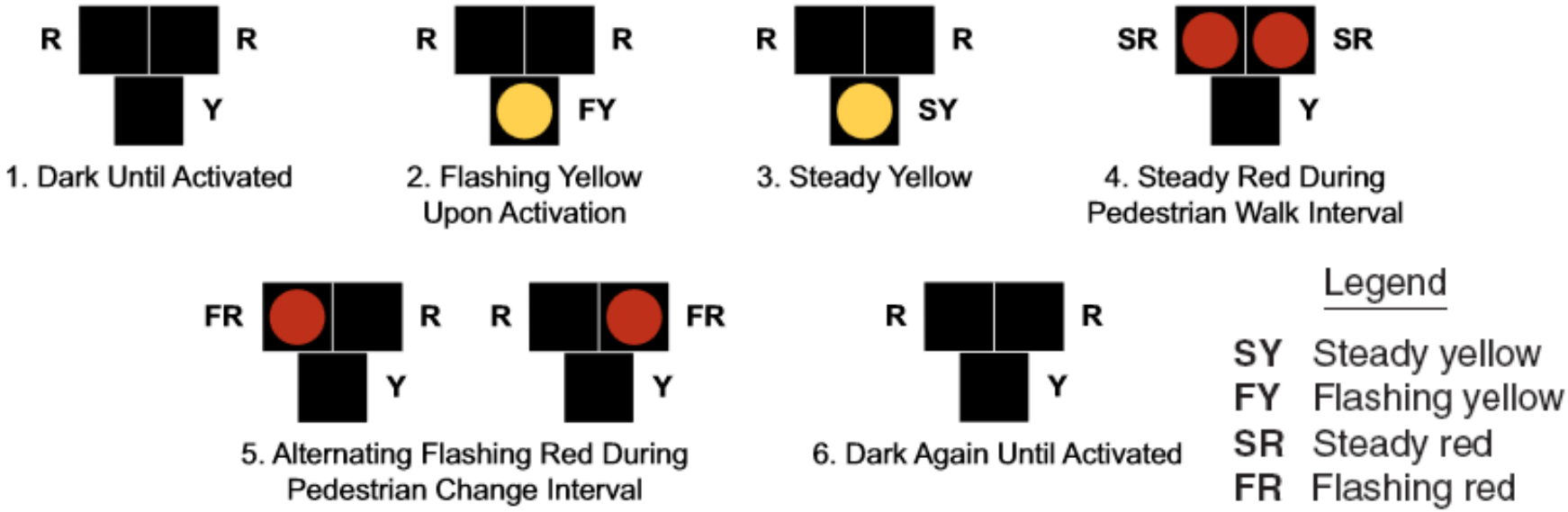
HAWK Safety Results

- 21 treatment sites
  - 38% 6 lanes, 62% 4 lanes
  - 52% 40 mph, 43% 35 mph, 5% 30 mph
  - **All at stop-controlled intersections/major driveways**
- 102 unsignalized intersections for reference group
- Statistical significant changes:
  - **29% reduction in total crashes**
  - **69% reduction in pedestrian crashes**

Pedestrian Hybrid Beacon (PHB)

- Added to the 2009 MUTCD / 2011 MMUTCD
- Name = Pedestrian Hybrid Beacon (Chapter 4F)

Figure 4F-3. Sequence for a Pedestrian Hybrid Beacon



Note: An optional steady red clearance interval may be used after Interval 3 and before Interval 4.

PHBs are Being Used in Michigan

- Ann Arbor
- Detroit
- West Bloomfield
- Ypsilanti
- Macomb County
- Oakland County
- Other??

PHB Anticipated Changes for Next Edition

- NCUTCD (2011) voted to remove following restriction:
  - *The pedestrian hybrid beacon should be installed at least 100 feet from side streets or driveways that are controlled by STOP or YIELD signs*
- NCUTCD (2011) voted to add:
  - If a pedestrian hybrid beacon is installed at or immediately adjacent to an intersection with a side road, vehicular traffic on the side road shall be controlled by STOP signs.

In-Roadway Warning Lights

MMUTCD Section 4N

2011 MMUTCD

- "…special types of highway traffic signals installed in the roadway surface to warn road users that they are approaching a condition on or adjacent to the roadway that might not be readily apparent…"
- Confined to pedestrian crossing applications
- Height shall not exceed 0.75 inch above surface
- Shall be flashed and not steadily illuminated

In-Roadway Warning Lights at Crosswalks

- Characteristics:
  - Crosswalks with warning signs
  - Pedestrian actuation
  - Entire length of crosswalk on both sides
- Maintenance:
  - Replace bulbs/LEDs
  - Remove snow and road debris
- Yielding: 50-90% (early ‘00s)

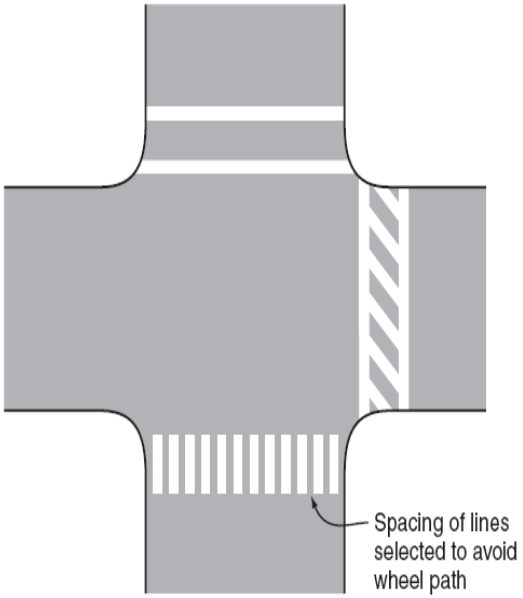
Photo: TTI

Crosswalk Markings

Changes are Coming to the Manual

Concerns

- Minimal attention given to selecting crosswalk marking style (staff turnover can increase this concern)
- MUTCD allows numerous options for flexibility, but perhaps clearer direction is needed
- Need research to show specific benefits of different styles

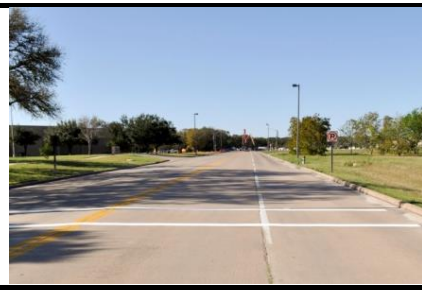


2009 MUTCD

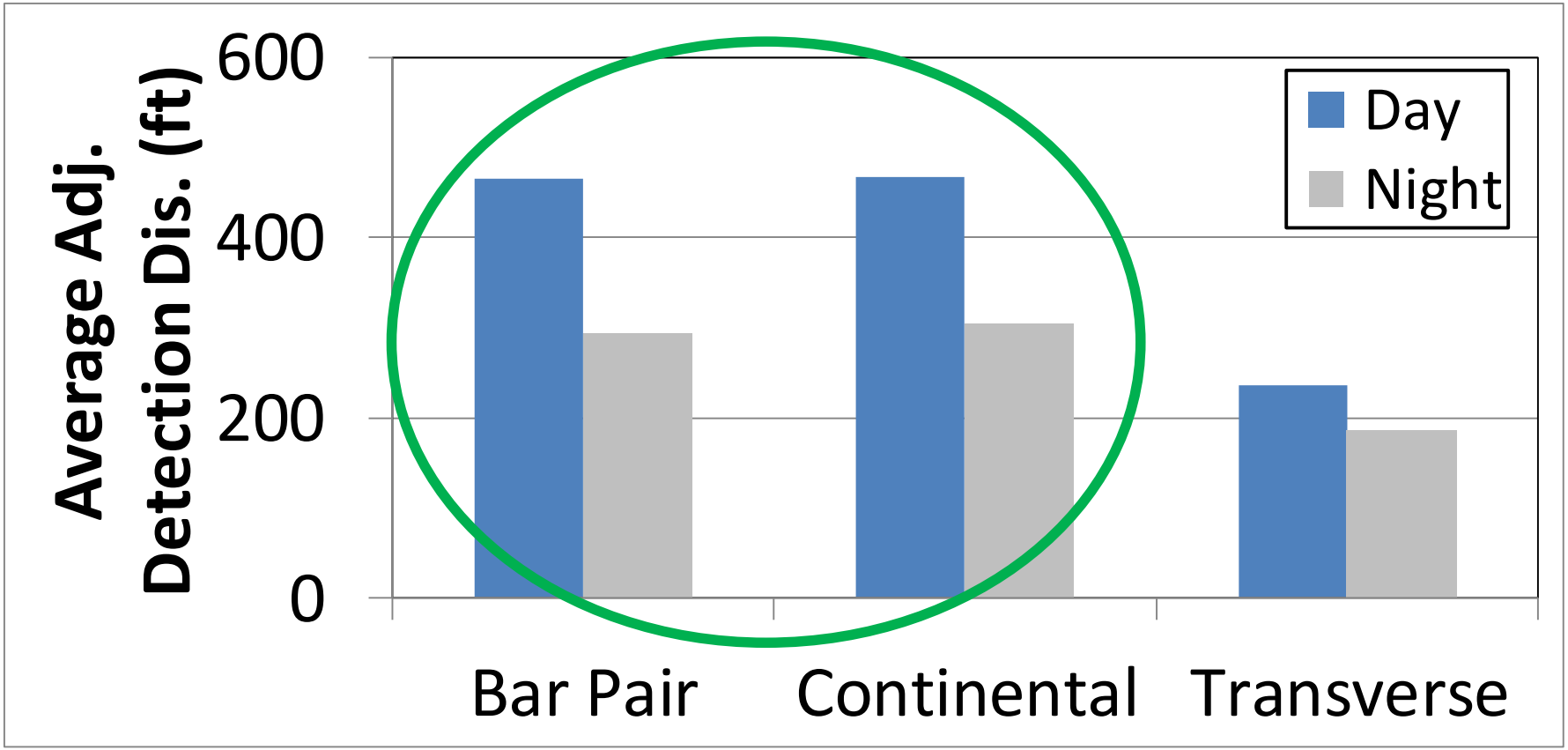
FHWA Study on Crosswalk Markings

- Objective = investigate relative visibility of crosswalk marking patterns (detection distance)
- Approach
  - **Open road** course on TAMU west campus
  - Participant in instrumented vehicle verbally indicating when crosswalk (or speed limit sign or turn arrow) is visible

Crosswalk Patterns

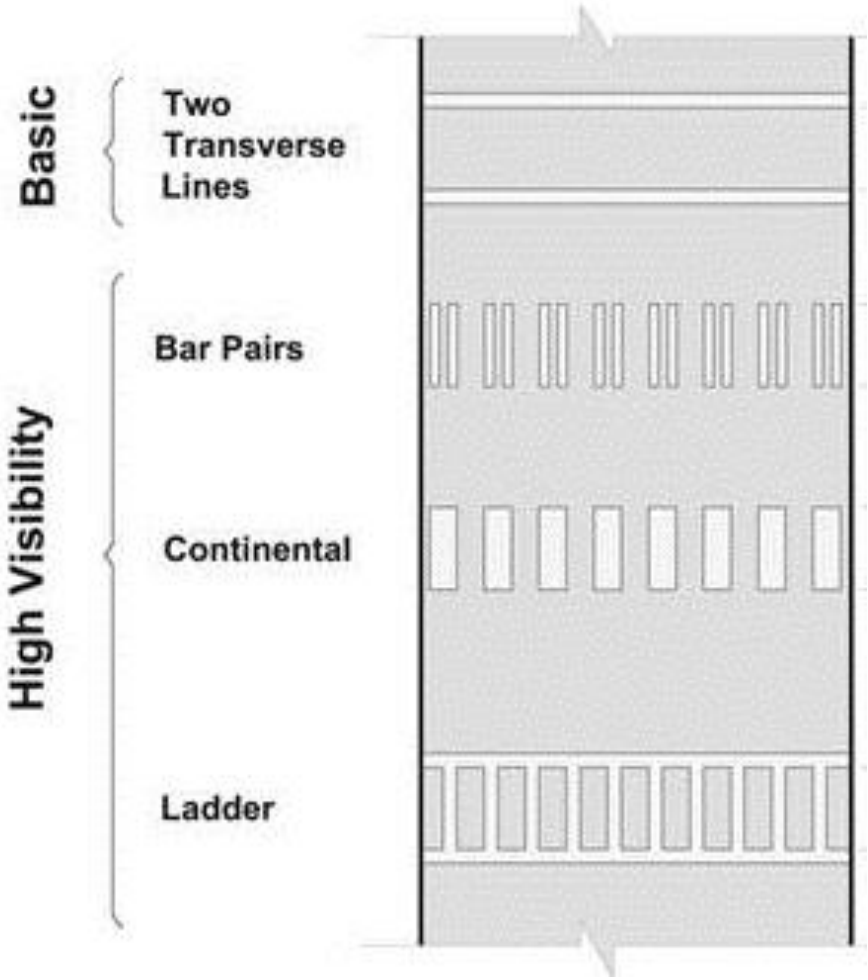
	Bar Pairs	Continental	Transverse
Group 1 45 Rural			
Group 2 30 Mixed			
Group 3 30 Urban			
	Bar	Con	Tra

Crosswalk Detection Distance
Key Finding = Light / Marking



Crosswalk Recommendations
Potential Changes Approved 6-23-11

- High-visibility markings
  - Defined
  - Install at non-intersection locations
- If 35 mph speed limit, 8 ft crosswalk width



Pedestrian Rapid-Flashing Beacon

Being Considered for the Manual

FHWA Interim Approval

- Optional use of rectangular rapid flashing beacons (RRFB)
- Pedestrian and school crosswalks across uncontrolled approaches
- July 16, 2008

Photos: TTI

Research – RRFB Driver Yielding

Study	# Sites	Driver Yielding	Unique Characteristics
2010 FHWA	22 (most in St. Pete)	72 to 96% activated	Original study, multiyear (2 yrs+ data)
2009 FHWA	2 (Miami)	55 to 60% day 66 to 70% night	Day and night
2009 Florida	1 (St. Pete)	35% overall 54% activated	Trail crossing
2011 Texas	1 (Garland)	80% activated	School, overhead
2011 Oregon	2 (Bend)	83% activated	45 mph
2014 Texas	22 (most in Garland)	34 to 92% activated	Significant: city, PSL, crossing dist, 1/2 way

National Committee on Uniform Traffic Control Devices

- RRFB →Signals Technical Committee (STC)
- STC would like answers to several questions before developing draft language
  - Why rectangular? Would circular be OK? Size?
  - Could the beacons be mounted above? Within?
  - Are there optimal flash rates & flash patterns?
  - What is the proper intensity?
  - What about potential for seizures?
  - Others

Research Studies

- Shape: circular or rectangular (C vs R)
  - Completed
- Flash pattern: 3 tested (Pattern)
  - Completed
- Beacon location: above or below the sign
  - Ongoing

C vs R: Object Detection on Closed Course

- Certain assemblies → shorter object detection distance (i.e., drivers had to be closer to detect object, which is not desirable)
  - Daytime: shorter for R-B compared to C-B12, C-B8, R-A, 155 to 167 ft differences (significant)
  - Nighttime: shorter for R-B compared to C-B12, 37 ft difference (significant)
- Selected R-B and C-B12 for open road

R-B

C-B12

Photos: TTI

C vs. R: Data Collection

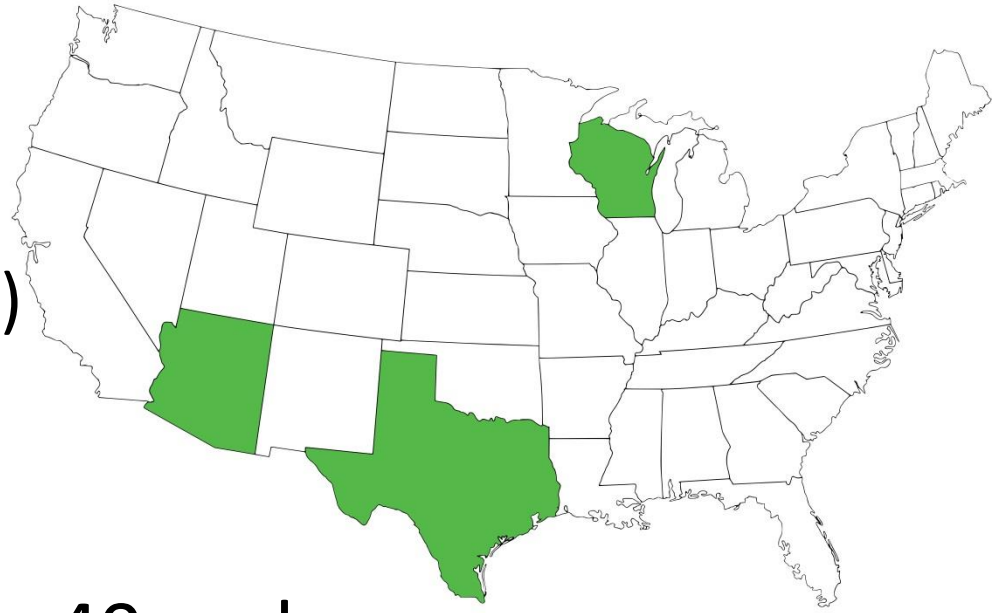
- Daytime
  - 40 staged pedestrian crossings minimum
  - All sites
- Nighttime
  - Possible due to travel arrangements
  - 40 crossings goal
  - One site per city for both shapes

CRFB

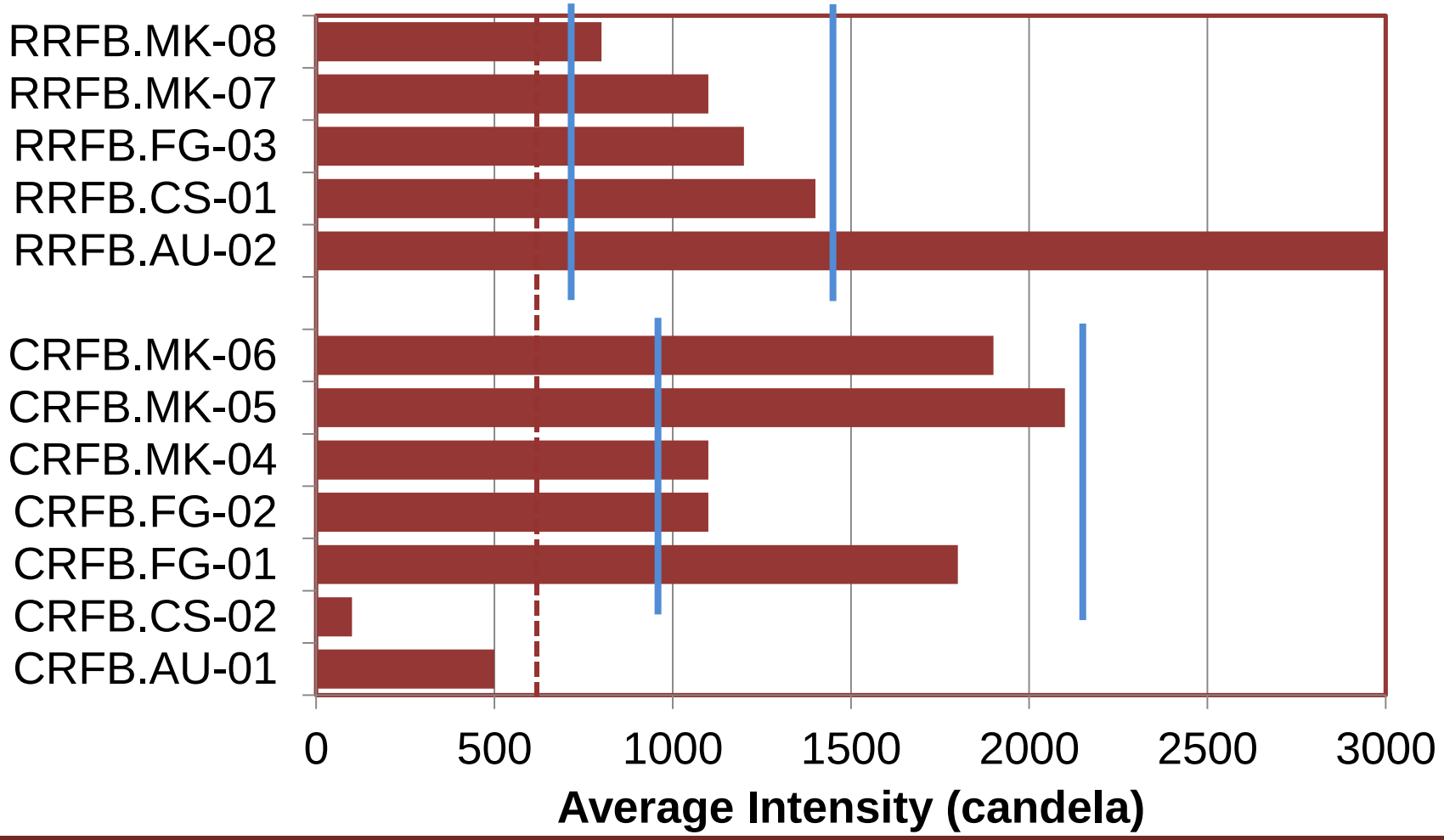
RRFB Photos: TTI

C vs. R: Sites

- 12 Sites:
  - Austin, TX (2)
  - College Station, TX (2)
  - Flagstaff, AZ (3)
  - Milwaukee, WI (5)
- Speed limit: 30, 35, or 40 mph
- Number of lanes: 2 to 6 lanes



C vs. R: Brightness



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C vs. R: Preliminary Findings

Device	Day – Number of Staged Ped	Day – Driver Yielding	Night – Number of Staged Ped	Night – Driver Yielding
RRFB	774	59%	180	72%
CRFB	753	63%	152 (171)*	68% (49%)*

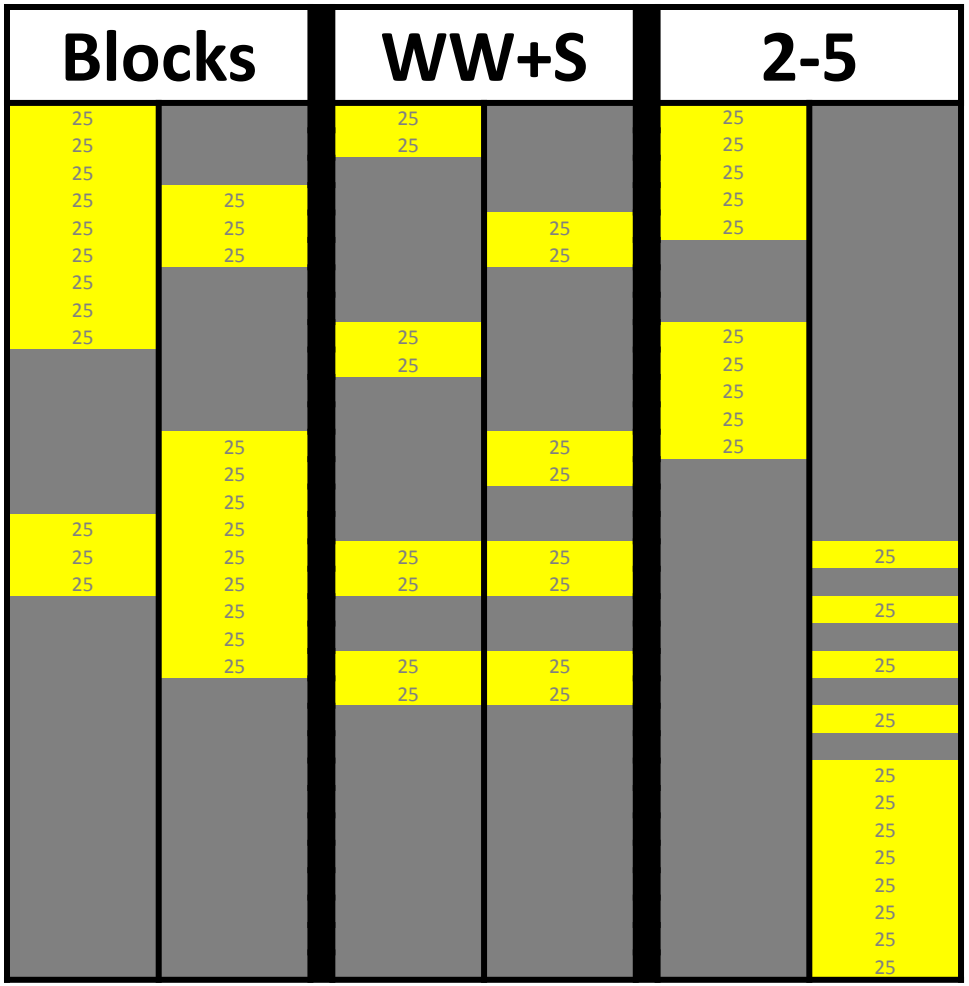
*includes site with lowest brightness

C vs. R: Results

- All staged ped data, brightness not included
  - No difference between beacon shapes (circular and rectangular)
  - No difference day/night
- Crossing data when brightness is available
  - Statistically significant:
    - Night / Day
    - Intensity at night

Pattern: Objective

- To compare driver yielding behavior to selected flash patterns
- Are there patterns that are simpler or have greater dark periods that are as effective as the 2-5 pattern?



Pattern: Equipment

- 8 sites in College Station or Garland, TX
- Temporary light bar and controller – key elements

Photos: TTI

Pattern: Driver Yielding

- Staged pedestrian crossings
- 40 crossings for each flash pattern
- All 3 flash patterns tested at each site
- Flash pattern presentation order randomized

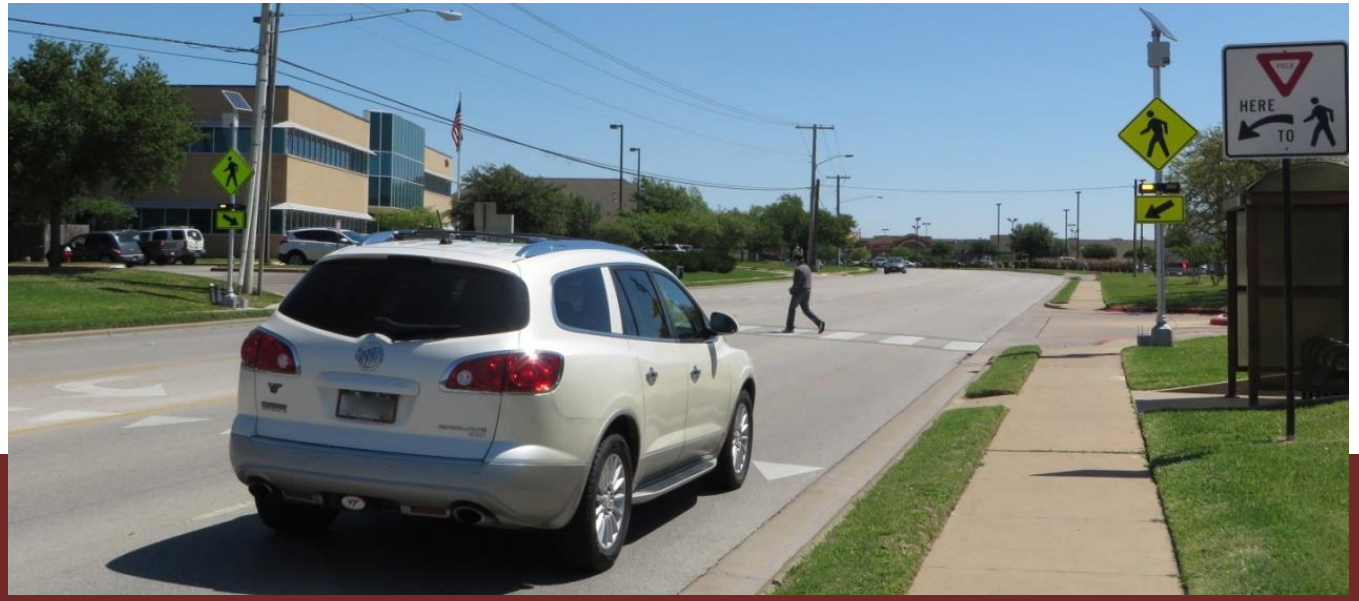


Photo: TTI

Pattern: Conclusions

- Average driving yielding for each pattern (across all 8 sites):
  - WW+S: 80%
  - Blocks: 80%
  - 2-5: 78%
- Data for each crossing used in analysis
- After controlling for crossing distance, city, and site, there is **no evidence of a difference between Flash Patterns**

Pattern: Characteristics

	Blocks		WW+S		2-5	
Left (L) or Right (R)	L	R	L	R	L	R
On time (ms)	300	300	200	200	250	300
Percent of cycle for a given beacon with the beacon on	38%	38%	25%	25%	31%	38%
Off ratio = percent of cycle where both beacons are dark	**44%**		**63%**		**31%**	

RRFB: Conclusions

- RRFB = more effective than no treatment or continuously flashing yellow beacon(s)
- Findings from 6 studies + several ongoing FHWA studies → driver yielding range from 22 to 98%
  - Large range an indication that other variables affect driver yielding results!
  - Variables found to influence yielding: crossing distance, one-way or two-way, City, brightness
  - Variables that may influence yielding: posted speed limit, time since installation, volume

RRFB: Conclusions & Action

- Shape (circular or rectangular) → similar driver yielding results (open road study)
- Pattern → similar driver yielding results for 3 patterns tested
  - Therefore, use pattern with more dark time (WW+S)
- Actions on C vs R findings:
  - STC of NCUTCD → motion to allow either circular or rectangular beacons with pedestrian treatments with rapid flash patterns

RRFB: Conclusions & Action

- Shape (circular or rectangular) → similar driver yielding results (open road study)
- Pattern → similar driver yielding results for 3 patterns tested (open road study)
  - Therefore, use pattern with more dark time (WW+S)
- NCUTCD STC (June 2014) → motions to support using either circular or rectangular and to support using other patterns

FHWA Action

- FHWA (July 25, 2014) Official Interpretation
  - Permit use of either 2-5 or WW+S
  - Favors WW+S
    - Greater percent of dark time (easier to read sign and see waiting pedestrians)
    - Less total on time (more energy efficient)

RFB Questions Being Asked

- Closed course indicates benefits for location beacons above sign
  - TTI currently collecting data to investigate
- Several combinations
  - Flash rate, flash pattern, brightness, shape and size of beacons/LEDs, placement (within, top, bottom, etc.)
    - What is optimal?
    - What about glare?

QUESTIONS

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